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ABSTRACT

This study examined the impact of a systemic reform initiative to implement standards-based mathematics and science teaching and learning in one urban school district, noting its effect on teachers, principals, students, and classroom practice. Participants were a sample of elementary and secondary schools involved in the Milwaukee Urban Systemic Initiative (MUSI). Researchers collected data via interviews with principals, teachers, and students and observations of mathematics and science instruction, emphasizing: the MUSI's impact; whether teaching was standards-based; opportunities for teacher collaboration; and leadership for mathematics and science. Most elementary and middle school teachers felt the MUSI had a great impact, but high school teachers saw little use for it. Teachers wanted more collaboration time, stronger leadership, and continuation of the MUSI. Movement toward becoming a community of learners was apparent in some schools. Principals recognized the need for multiple methods of teaching and for keeping teachers current regarding instructional materials. Principals also acknowledged the need for teacher collaboration but mentioned lack of time during school days. Leadership varied across schools. Students reported enjoying mathematics and science more and applying themselves more when challenged. Observations of classroom practice showed that much instruction was not standards-based, though at all levels in both disciplines there were some strong examples of it. (SM)

Voices of Reform:
Infusion of Standards-based Mathematics and Science Teaching in an Urban District

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Pressure to reform educational systems is commonplace throughout the country, indeed the world. "Our need for some basic agreement about educational objectives is particularly clear today with strong pressures to set or redefine national educational standards nationwide, especially where there is no history of nationally specified curricula such as Norway, Australia, and the United States" (Black & Atkin, 1996, p. 19). An effort to reform the manner in which mathematics and science are taught through the infusion of standards is underway in districts across this country. Fullan (1991) cautioned us that "reform is simply not putting into place the latest policy. It means changing the cultures of the classrooms, the schools, the districts, the universities, and so on" (p. xiii). The urban district examined here is in the midst of a systemic reform initiative to implement standards-based mathematics and science teaching and learning. This study focused on the impact of this reform effort after two years on teachers, principals, students, and classroom practice.

Background

One of the daunting tasks facing those working with systemic reform efforts is the compilation and the analysis of vast amounts of data. That task is further complicated by the fact that these efforts have no history in this country from which to draw insights (Mervis, 1998). "Most current systemic reform initiatives are too recent to have run their course in a way that permits confident data-driven conclusions about them" (Knapp, 1996, p.228). With time, the quantitative data will be gathered from reform efforts, but for an effort-in-progress, qualitative data provides invaluable information from those involved in the day-to-day experiences of reform. Knapp reaffirmed the efforts to gather data reflective of the "voices" in an effort when he says that in these efforts "qualitative strategies may offer a deeper understanding and ultimately, more useful insights to those who wish to pursue these reform strategies" (p. 257).

Knapp performed an aggregate study of various systemic reform efforts. He found that better teaching of mathematics and science will result when all elements of the system that bear most directly on the classroom are aligned with challenging standards such as the national standards for mathematics and science (National Council of Teachers of Mathematics, 1989, 1991; National Research Council, 1996).

Urban Systemic Initiatives Program

The Urban Systemic Initiatives (USI) program is an effort of the National Science Foundation (NSF) that targets large urban school systems. Its purpose is to support "comprehensive and systemic effort to stimulate fundamental, sweeping, and sustained improvement in the quality and level of K-12 science, mathematics, and technology education" (Williams, 1998, p. 7). The goal of the USI is sustainable implementation of high-quality, standards-based teaching for the purpose of attaining system-

wide increases in students' learning of challenging mathematics and science. According to NSF, the emphasis of systemic reform is comprehensiveness and synergy by elevating teaching and learning standards, enriching instructional materials and pedagogy, and refining methods to assess students' grasp of mathematics and science related subjects. Underlying this approach is the belief that improved student achievement will most effectively be achieved through a system-wide reform of mathematics and science instruction and that effort is ongoing and coordinated across educational settings in contrast to traditional piecemeal approaches. This suggests that the entire process is synergistic and aligned; that is, policies are formulated at the same time that educators and community members develop curriculum, alter instructional methods, and realign assessment procedures.

Cities with the largest numbers of school-aged children living in poverty, as determined by the 1990 census, are eligible to participate in the USI program. USI awards have been granted to 22 of the eligible cities (NSF, 1999). The first awards were granted in 1994 to eight cities. This first cohort included Baltimore, Chicago, Cincinnati, Dallas, Detroit, El Paso, Miami, New York City, and Phoenix. In 1995, seven more cities joined the initiative. This second cohort included Cleveland, Columbus, Fresno, Los Angeles, Memphis, New Orleans, and Philadelphia. The third cohort joined in 1996 and included Milwaukee, San Diego, San Antonio, and St. Louis. In 1998, the fourth cohort was named and it included Atlanta and Jacksonville. Each city is eligible to receive up to $15 million over five years.

Milwaukee Urban Systemic Initiative

The Milwaukee Public Schools (MPS) joined the USI effort in 1996 as part of the third cohort. MPS had a student population of approximately 101 963 students in 1997-98. The student population consisted of 80 percent minority students—61 percent African American, 13 percent Hispanic, one percent Native American, four percent Asian, 20 percent Caucasian, and two percent other. Seventy-nine percent of the elementary students were eligible to receive free or reduced price lunch. The district had 154 schools, excluding alternative and partnership schools—114 elementary schools, 22 middle schools, 18 high schools.

The Milwaukee Urban Systemic Initiative (MUSI) includes three components. The first component involves mobilizing and supporting communities of learners at all levels—classrooms, schools, district, and city. The second component is the development of a cadre of teacher leaders referred to as Mathematics and Science Resource Teachers (MSRT). The third component is the establishment of a mathematics, science, and technology center.

Each year, a group of elementary, middle, and high schools are identified as targeted MUSI schools and additional schools are brought into the reform effort each year. The MSRT is a full-time position and each MSRT, in general, is assigned to work with the staff at two targeted MUSI schools for two years. In 1996-97, 51 schools became the first wave of MUSI schools and 25 MSRTs were selected to work within these schools. In 1997-98, 30 additional schools were targeted as the second wave schools and an additional 15 MSRTs were identified. Thus, during the second year of MUSI, 81 schools were being targeted and the cadre of MSRTs totaled 40.

Methods

This study was part of the overall evaluation of the Milwaukee Urban Systemic Initiative (MUSI). A sample of first and second wave MUSI schools were selected to participate. The following four questions guided the collection and analysis of data.

(1) What has been the impact of the Milwaukee Urban Systemic Initiative?

(2) Is the teaching of mathematics and science standards-based?

(3) What opportunities are teachers provided for collaborative examination and discussion of the teaching and learning of mathematics and science?

(4) What leadership exists within the schools for mathematics and science?

Subjects

Data were collected from a purposeful sample of MUSI schools. The criteria for selecting First Wave schools included being a site visit school during the previous year and having the same MSRT for both years. Second Wave Schools were selected that had the same MSRT for the entire year. No two schools with the same MSRT were selected. A balance of first and second wave schools were selected at each level—elementary, middle, and high—that were distributed across the geographic regions of the district. If more than one school fit the criteria at any level, wave, or region, a random selection was made. The sample included four elementary, three middle, and two high schools. Five schools were from Wave One and the other four were from Wave Two. See Table 1 for a profile of each school.

Table 1. School Profiles (based on 1997-98 data)

School	Wave	Level	Student Enrollment	Percent Minority	Percent Free/Reduced Lunch
School A	2	elementary	446	69	64
School B	1	elementary	564	53	74
School C	2	elementary	360	95	94
School D	1	elementary	394	92	75
School E	1	middle	745	81	82
School F	2	middle	761	76	87
School G	1	middle	947	92	82
School H	2	high	1517	75	61
School I	1	high	1542	75	57

Data Sources

A site visit was conducted at each school toward the end of the school year. Data were collected from a variety of sources. These included (a) interviews with principals, (b) interviews with groups of teachers, (c) interviews with groups of students, (d) observations of mathematics instruction, and (e) observations of science instruction. See Table 2 for a listing of the data collected.

Table 2. Data Sources

School	Principals Interviewed	Teachers Interviewed	Students Interviewed	Mathematics Lessons Observed	Science Lessons Observed
Elementary	3	20	14	17	14
Middle	3	17	18	11	12
High	2	11	8	6	8
Total	8	48	40	34	34

Procedures

The data were collected by site visit teams. Each team was comprised of two to three individuals. Some team members varied from site to site, with most individuals conducting site visits to at least three different schools. Site visit teams spent one day at each site collecting data through interviews and observations. The qualitative data collected from each site provided a rich array of views on the reform effort. Reduction techniques were used to synthesize and summarize the data (Huberman & Miles, 1994; Stevens, Lawrenz, & Sharp, 1993).

Interviews. Two groups of four teachers were scheduled to be interviewed during each of the site visits. However, due to scheduling difficulties only one group of teachers was interviewed at three of the schools. See Appendix A for the teacher group interview protocol.

Individual interviews were scheduled with the principal at each site visit school. However, only eight principals were interviewed due to an unexpected situation at one of the schools on the day of the site visit. See Appendix B for the principal interview protocol.

One group of six students was scheduled to be interviewed at each school. The site visit team was unable to interview a group of students at one of the elementary schools due to an unexpected situation at the school on the day of the site visit. See Appendix C for the student group interview protocol.

One member of the site visit team conducted each interview using a semi-structured interview protocol that consisted of open-ended questions. Each interview was approximately 20 to 30 minutes long. The interviews were recorded on audio tape. During the student and teacher interviews another member of the site visit team took extensive notes and the audio tapes were used to clarify and extend the written notes. The principal interviews were transcribed.

The data were read and reread and then summarized for each question. Illustrative comments were identified to generate three sets of interview summaries—students, teachers, and principals. The summaries were gleaned from the analysis of the interview data. These summaries should be considered as representative of ideas expressed by the participants.

Observations. Observations of students learning mathematics and science were conducted during each site visit. Observations were scheduled for four mathematics lessons and four science lessons at each school. However, due to scheduling problems or opportunities the number of observations in each school ranged from two to six for mathematics and from three to five for science.

Observations of mathematics and science lessons usually occurred for an entire class period. Observers made written notes using a classroom observation guide. Completed observation forms were separated into elementary, middle, and high school levels and then further separated by content area. Then several readings of the completed observation forms occurred. Then a rubric was used to rate each observed lesson in three areas: (1) standards-based instruction, (2) equity, and (3) community of learners. The rubric is included in Appendix D.

To establish inter-rater reliability, two raters first reach consensus on a sample of six observations. Next each person rated a random selection of six observations with 85.4 percent agreement with either perfect agreement or variance of one. They then discussed each of these observations and reached

consensus on their ratings. Then one of the individuals rated the remaining observations. If she was unsure of any rating, the two raters conferred and reach consensus.

Teacher Voices

Small groups of teachers were interviewed in each of the Milwaukee Urban Systemic Initiative (MUSI) targeted schools selected for this study. The teachers, as representatives of their schools, voiced their impressions, appreciation, successes, and frustrations with the mathematics and science reform effort. Their voices will be heard in this section on the following topics: (1) impact of MUSI, (2) mathematics and science instruction, (3) leadership, and (4) collaboration.

Impact of the Milwaukee Urban Systemic Initiative

The teachers were asked to talk about the ways that MUSI related activities helped them improve their mathematics and science teaching. As shown in Table 3, most teachers in the elementary schools felt MUSI had a great deal of impact as did the middle schools. However, most high school teachers saw little use for MUSI in their schools. Some of the teacher comments are listed in Figure 1.

Table 3. Impact of MUSI from Teacher Perspectives

Level	n	Unaware	None	Little	Some	A Great Deal
Elementary	7	14%	0%	0%	0%	86%
Middle	15	0%	0%	27%	0%	73%
High	4	0%	75%	0%	25%	0%

Figure 1. Teacher Comments Regarding Impact of MUSI

Elementary School Teacher Comments

- The whole science process for one thing. I would have never been doing that at my grade level before MUSI.
- I think too the whole thing with the NCTM standards making sure that you cover those in your math teaching, and then with the staff development it really helps me stay on track.
- The math classes and the standards classes were really helpful.
- MUSI has had a very positive impact on this school.
- It is a valuable program that should be continued, but we should have the MSRT full time.
- I like the classes I have taken through MUSI. I like the idea that you can take what you've learned and do it your class and get graded on that. And then you can come back and share all that.
- I am really sorry that we are not going to be a part of MUSI next year. I think that there are going to be many opportunities that we are missing.

Middle School Teacher Comments

- I like the MSRT. The MSRT has taught me to do some new and innovative things with my kids. As a matter of fact, it worked out so well, it helped to stabilize this classroom.
- The class that we all took last spring, the teaching of algebra, that's the emphasis we are taking this year with our students. I know that I have used a lot of that information. I know that it has given me a focus and a new direction this year and it has been extremely helpful.
- I do more cooperative learning, more hands on. I don't feel as nervous.
- We are trying very hard to incorporate more concept mapping, frame activities, weekly assessment of learning, static questions. We are letting them guide their experimentation, we are saying "here is our problem, how can you best go about it?" It has opened our eyes to things that we knew we should be doing but haven't necessarily been doing. It has been real good overall.
- I feel the way I am teaching math this year is light years ahead of the way I taught math last year, not that it was shabby, but I really feel renewed, affirmed, and all of those positive things.
- I think the kids are finally realizing because of the emphasis we are putting on math and science how important it is, that they need it . We also have some people who are going back to get certified to teach math and we have people who are taking graduate courses. The emphasis is tremendous. It is so important.

High School Teacher Comments

- Hasn't had any impact for me. I don't even know what it is as a whole.
- I'm not really sure how it has affected us.
- I think next year we need a lot more coordination and I think we need how to figure out how to use the MSRT better because I think right now the MSRT is not being fully utilized.
- We need teachers in the classroom, not resource teachers right now.
- What is really frustrating is that they are pulling good teachers out of a building to be an MSRT when we have a teacher shortage.

As shown in Table 4, elementary school teachers overwhelmingly reported that the Mathematics/Science Resource Teachers (MSRT) assigned to their school provided a great deal of help to them as a source of support, materials, ideas, and organizational skills. Some middle school teachers saw the MSRTs as providing them with the psychological comfort of feeling more at ease teaching a lesson as a result of the MSRTs' mentoring and feedback on their teaching performance. The high school teachers reported not seeing their MSRT for an extended amount of time, not being alerted to professional development classes, and some were not aware of who served as the MSRT in their school. Whereas other high school teachers reported that they did learn of classes, were able to obtain grant money, and discovered resources as a result of interactions with the MSRT. Some of the teacher comments are listed in Figure 2.

Table 4. Interaction with MSRT from Teacher Perspectives

Level	n	No Assistance	Little Assistance	Some Assistance	Much Assistance
Elementary	14	0%	7%	0%	83%
Middle	13	0%	1%	46%	46%
High	17	47%	24%	12%	18%

Figure 2. Teacher Comments Regarding Interaction with MSRT

Elementary School Teacher Comments

- If we need something or you're having problems with something or if you say, "Hey, my kids aren't getting this, is there anything else?" the MSRT will get resources for you.
- The MSRT has demonstrated some lessons for us. It is helpful to watch someone else teach.
- The MSRT has helped us get our act together. The MSRT would come in and demonstrate a lesson with you and be there to guide us.
- I wish we could have asked for the MSRT for one more year because the MSRT did wonders in or school. As a result, we are doing things a lot better in our school.

Middle School Teacher Comments

- I feel more comfortable with science and I am doing much more this year.
- You can come in days ahead of time and feel safe. The MSRT will bring you the materials and talk with you. And this last spring the MSRT actually came and sat in on a couple of classes. The MSRT didn't have to do that, but it was nice to know that the MSRT was there to support us.
- We use the MSRT a lot to do classroom observations and give us feedback on our teaching and questioning styles. The MSRT did about six observations for me. That was helpful. I don't know how we would have done that without the MSRT.
- The MSRT has helped the new science teachers a lot. Mostly for me it's been coordinating or finding out things.

High School Teacher Comments

- The MSRT has written grants for the science money as well as put things in my mail box making us aware of things that are available to us, like programs.
- The MSRT is always willing to help when you ask for something. When we were doing our portfolios, I told the MSRT I needed help two weeks straight and the MSRT was there.
- The MSRT has given me extra resources and the MSRT has been an extra body to help in the classroom.
- We tried to have a meeting with the science chair and some other people, but there was always a problem, so I am not sure that the MSRT was as effective as s/he could have been.
- Other than when you specifically ask the MSRT to do something, I am not sure that we use the MSRT at all.

Mathematics and Science Instruction

One goal of MUSI is to assist teachers in implementing standards-based methods for teaching mathematics and science. The teachers were asked whether they would characterize the mathematics and science instruction in their schools as standards-based (e.g. aligned with national and state standards). As shown in Table 5, all middle school teachers felt that some or most of their instruction was standards-based. In contrast, over half of the high school teachers felt the instruction was not standards-based. At the elementary level, the results were more varied. Eighty percent of elementary teachers felt the instruction was somewhat or mostly standards-based and the other 20 percent said that none or very little was standards-based. Some of the teacher comments are listed in Figure 3.

Table 5. Standards-based Mathematics and Science Instruction from Teacher Perspectives

Level	n	None or Little	Some	Most
Elementary	10	20%	50%	30%
Middle	6	0%	83%	17%
High	11	55%	45%	0%

Figure 3. Teacher Comments Regarding Mathematics and Science Instruction

Elementary School Teacher Comments

- We are not very focused as a staff as to what we want math to be.
- I would say more in math than in science.
- We try to make things, more hands-on, more integrated.

Middle School Teacher Comments

- We are trying to get people to use more manipulatives, more open-ended questions, more problem solving, more open story problem, real life situations. I see most people shifting away from the book.
- We have CMP and the proficiency standards and the benchmarks.
- I think that there are too many science topics so we have to just skim them. We should be going more in- depth.
- Science has become more focused this year since we have goals to focus on and the staff development has helped.
- I think a lot of times math is taught in a way for whatever keeps order in the room. Sometimes those hands-on activities don't get done because of classroom management, especially with the newer teachers.

High School Teacher Comments

- Some teachers follow the NCTM standards. As far as district math standards, are there any?
- For science, I don't know as far as state standards, I don't know if I have ever seen them. But we are with the MPS standards. I would say we come pretty close to agreeing with MPS.
- People quote the standards but don't apply them. We need changes in science. Math is not standards based either.
- Not everyone adheres to NCTM standards.
- Math is taught pretty traditionally in this school. All of our books are very traditional and some of our teachers are page-by-page, and still in rows of five. But we are starting to do some hands-on. But we are still pretty much, "Get out your assignment, go over it, see if they can do it."
- We use a lot of demonstrations with new ideas and hands-on in science. There is still the homework assignments. A lot of new technology as far as laser discs have been used pretty much by all of the teachers. A few teachers are using computers to pull things off of the internet for their classes, but mostly labs, lecture, hands-on and homework.

Leadership

The teachers were asked to talk about the leadership in their schools for improving the mathematics and science programs. Table 6 shows that varied individuals provided leadership across the schools at each level. At the elementary level, the principal, the Mathematics/Science Resource Teacher (MSRT), or a school implementor often provided the leadership. At the middle school level, teachers often provided the

leadership. At the high school level, about two-thirds of the teachers commented that there was no one providing leadership in mathematics or science. Some of the teacher comments are listed in Figure 4.

Table 6. Leadership for Mathematics and Science from Teacher Perspectives

Level	n	Principal	MSRT	Teachers	Implementor or Chair	Shared	Other	None
Elementary	20	30%	30%	15%	20%	0%	5%	0%
Middle	13	0%	0%	31%	15%	23%	8%	23%
High	6	0%	0%	0%	33%	0%	0%	67%

Figure 4. Teacher Comments Regarding Leadership for Mathematics and Science

Elementary School Teacher Comments

- I think the principal encourages us a lot by saying things like, "Yeah, we should do this because it will increase their knowledge."
- The principal provides the leadership and is receptive to new ideas and perspectives.
- And I think if there was not someone like the MSRT there to take the lead we would all be off in different directions. The MSRT is there and coordinates us.
- I think the MUSI person has been a real big impetus for change over the last two years. The MSRT is the one who brought Investigations in here.
- We work on committees. The school plan is divided into the content areas.
- The Implementor and the MSRT. Science has been a big project supported by school leaders.
- The Title I School to Work Implementor.

Middle School Teacher Comments

- I would say the teacher's take the first step then we convince the learning coordinator and the MSRT. We want the best and we realize what the kids need.
- I think that our commitment from our teachers is very strong. We are all very passionate about teaching. We also have a very good working relationship.
- I would say the learning coordinator. The learning coordinator will find an answer within 24 hours.
- The MSRT a little bit. Amongst the teachers we all share and there is really no leader.
- In math, I don't think anyone runs the show.

High School Teacher Comments

- The science department chair is the leader.
- In math it is within the department. We get good support from administration. We can go to workshops or be released to teach other courses. The administration is good about that.
- We have no major leader in science. It is pretty nebulous. A teacher will come up with an idea but lose control of it due to budget constraints. The principal supports the ideas, but is concerned with keeping the budget down. There are bigger issues here such as uncertified teachers.
- In math, nobody.
- Math, some teachers, but really nobody.
- That is taken care of more at the district level, at the central office, what is needed for each school.

Collaboration

A central premise of the Milwaukee Urban Systemic Initiative (MUSI) is the importance of building a community of learners around mathematics and science within each school. Within a community of learners framework, collaboration is a critical element for success. Opportunities for teachers, principals, implementors, department chairs, and MSRTs to discuss curriculum, implementation, and children's learning should be plentiful. Through sharing and de-privatization of practice, opportunities arise to further improve instruction and enhance student learning (Kruse, Seashore Louis, & Bryk, 1997).

The teachers were asked to talk about the opportunities they had to get together to discuss mathematics and science in regard to the curriculum, teaching strategies, and students' learning. As shown

in Table 7, about three-fourths of the middle and high school teachers interviewed felt they had some time to a great deal of time to meet and discuss teaching, curriculum, and student learning. The elementary school teachers, on the other hand, indicated that they had no time or only some time to discuss the teaching and learning of mathematics and science with their colleagues. Some of the teacher comments are listed in Figure 5.

Table 7. Collaboration for Mathematics and Science from Teacher Perspectives

Level	n	None	Some	Often
Elementary	16	25%	63%	13%
Middle	33	15%	55%	30%
High	12	25%	33%	42%

Figure 5. Teacher Comments Regarding Collaboration for Mathematics and Science

Elementary School Teacher Comments

- We meet about 30 minutes a week for our grade level.
- If you are piloting Investigations right now we have meetings one Tuesday a month to talk about what were doing, if we need any help, any questions.
- The school plan is that we are divided into different committees. It's very good since we have time to discuss issues. But lately not everyone has had a chance to add to discussion.
- We have a chance during Banking Days.

Middle School Teacher Comments

- For math, we meet biweekly for subject area meetings and once a month after school. We either talk about what we are teaching at the time, what worked for one teacher, we share information. It's a time to find out about meetings in the district, training, and so on.
- The science teachers meet to discuss how we are going to teach each unit. We share ideas and help teachers feel comfortable teaching a topic. We help them with activities too.
- Next year we will have someone cover in-house for 2 hours so we can meet with the unit teacher and go to someone else's classroom and see what they are doing.
- Periodically, we have area content meetings to put together things. Our science department talks very often.
- This year has been very difficult this year so we've decided to try mornings before school next year.

High School Teacher Comments

- We have Banking Days and in-services. We do have teachers paired to visit each other's classroom, to go one level up, and see what the other classes are doing.
- As far as getting together with colleagues, it's not structured. If we need to talk we talk informally. I'll ask a more experienced teacher so I don't have to reinvent the wheel. At least 3 or 4 times a week I talk with other science teachers and then with math at least once a week.
- We have monthly department meetings, Banking Days. We have no common planning time.
- We have meetings before the school year starts. We get a book and then it's explained to you how to correlate the curriculum and then we are pretty much left to do it ourselves.
- Only if I force the time. I only talk to the department chair. We have no time on Banking days and we hardly talk about curriculum.
- For math, this is probably my own fault, but I am away from the other math teachers so I don't communicate with them very often. When I do it is usually at the department meetings.

Summary

These interviews showed the teachers would like more time to collaborate, stronger leadership for their curriculum, and for the MUSI project to continue in their schools beyond the allotted time of two years. Taken together, the responses across grade levels showed only some agreement on how mathematics and science should be taught and some movement toward standards-based teaching.

Movement towards becoming a community of learners was apparent in some schools. Teachers' responses indicated the desire to meet with colleagues to share insights and ideas. While the majority of the

answers fell in the "some" time to collaborate range, the question arises from these interviews whether the time that is currently provided is used for substantive discussion of teaching and learning.

Many teachers indicated that MUSI did provide assistance in working out the vision for and implementation of mathematics and science instruction. Teachers at the elementary and middle school levels indicated that the MSRT and MUSI provided guidance, leadership, and training. The desire to continue both the MSRTs' term in the schools as well as the ability to take university courses to enhance their teaching emerged as key inputs leading to MUSI's success in these schools.

Principal Voices

The principals from eight of the nine schools selected for this study were individually interviewed. The principals voiced their perspectives of the Milwaukee Urban Systemic Initiative and the challenges of the mathematics and science reform effort within their schools. Their voices will be heard in this section on the following topics: (1) impact of MUSI, (2) mathematics and science instruction, (3) leadership for mathematics and science, and (4) collaboration among teachers.

Impact of the Milwaukee Urban Systemic Initiative (MUSI)

The principals were asked to talk about ways in which MUSI had assisted their schools in improving the mathematics and science programs. The principals felt that MUSI was providing valuable assistance in moving their mathematics and science programs forward. Common responses from the principals were that MUSI helped to focus and coordinate the schools' mathematics and science programs and demonstrated new teaching methods. In the elementary schools, the principals mentioned that more focus was now given to mathematics and science throughout the school. Middle school principals reported seeing an increase in extended student projects. The high school principals noted that the MSRT had helped to initiate cross-departmental meetings which have moved the teachers to work together. Some of the principal comments are listed in Figure 6.

Figure 6. Principal Comments Regarding the Impact of MUSI

Elementary School Principal Comments

- Our MSRT has been helpful by going into classes, doing lessons, and bringing in materials.
- Science was our weak area and our MSRT has made a huge difference there.
- MUSI forces us to focus on math and science. Science is now in the forefront.
- In an elementary school the focus is usually on reading. Now we also focus on math and science too.
- I have seen more teachers using new materials and willing to volunteer for things now.
- Next year we are piloting Investigations and that never would have come about without the support of MUSI.
- I am just very thankful that we were a first wave school and we could purchase the services for a third year. Two years is just not enough. You cannot effectively change and reform in that amount of time. To try it for two years and just drop it, that's not a good idea. It is a very wise choice to continue to offer this. We will do whatever we can to continue this.

Middle School Principal Comments

- I see a lot more math and science projects. The teachers who took classes are doing a better job teaching algebra now and showing kids the applicability to their lives.
- The best part of MUSI has been having someone here to coordinate mathematics and science.
- Having the support of the MSRT has been the best part. The MSRT is able to go in and work one-on-one with teachers. The MSRT understands the curriculum and is a valuable resource.

- I think MUSI and our MSRT are really good. You need to have someone in the classroom who is non-threatening and we are really lucky to have that in our MSRT.

High School Principal Comments

- Through the MSRT, we have the opportunity to start meeting and working together across disciplinary departments. I have also started seeing projects being done through the MSRT facilitating. The MSRT does the leg work and makes it easier for teachers to do things.
- The MSRT has really made an impact for us. The program has really made us focused.
- One of the things I would say is that MUSI has given us a direction to the mathematics and science programs. We know that there are things that need to be done. I don't think we would be where we are now without MUSI.

The principals were also asked to talk specifically about the work of the MSRT within their schools. Across grade levels the most common work cited was the MSRT modeling lessons and initiating or participating in meetings with teachers. Elementary and middle school principals indicated that movement of teachers toward using inquiry-based teaching methods was due in large part to the MSRTs' work. These principals were also appreciative of he MSRTs' assistance with grant writing. In the middle schools and high schools, a commonly cited part of the MSRTs' work involved using classroom observations as a vehicle to help teachers improve their teaching. Some of the principal comments are listed in Figure 7.

Figure 7. Principal Comments Regarding the MSRT

Elementary School Principal Comments

- The MSRT has moved from spoon-feeding the teachers to making the teachers leaders.
- The MSRT has given in-services to the staff.
- The MSRT goes to the grade level meetings and keeps science and math at the forefront.
- The MSRT has written numerous Eisenhower Grants.
- The MSRT has brought many insights to me as the instructional leader as to what to look for.
- The MSRT has built up our science supplies and our supplies for math as well.
- We would not be moving forward with math and science reform if the MSRT was not here.

Middle School Principal Comments

- The MSRT meets with the teachers and tells them what needs to be done. I probably don't meet with him as much as I need to.
- I am sure that the MSRT has done more than I have observed or know, but (1) going into classrooms and observing teachers and critique their teaching. (2) The MSRT has worked hard to get the word out that teachers have to stop just teaching memorization and that they need to focus more on helping kids think and problem solve. (3) The MSRT is also available for 1.5 hours after school on Mondays to help them with any problems. (4) The MSRT has helped us with testing. (5) The MSRT has also acted as a conduit between us and the district.

High School Principal Comments

- The MSRT has done classroom observations and worked with teachers. The MSRT talked with them about things they could be doing differently, strategies they could use, and how to pull students into some of the lessons.
- The MSRT has also modeled lessons for several teachers.

Mathematics and Science Instruction

The principals were asked to describe the vision for mathematics teaching and learning within their schools and to comment on the implementation of this vision. All principals recognized the need for multiple methods of teaching. Whether it was through hands-on work or extended projects, the principals felt that allowing a variety of opportunities for students to learn was the most important aspect of their vision for instruction and curriculum in mathematics. The principals also recognized the need to bring teachers up-to-date regarding instructional methods. While the vision seemed to be fairly clear, none of the principals were satisfied with the implementation of the vision, but most responses indicated that the felt

they were on their way to a satisfactory implementation. Some of the principal comments reading mathematics instruction are shown in Figure 8.

Figure 8. Principal Comments Regarding Mathematics Instruction

Elementary School Principal Comments

- I really think kids need multiple ways of learning. That is a bit of a hard sell to the teachers because they want the book. I did hear this year that teacher's thought Investigations was very difficult to teach, but I also heard the kids loved it. That's when you know they are going to learn.
- The vision isn't quite there yet, but it is coming. They are going to be forced into it because that is the curriculum and they know how I feel.
- Basically, what we've looked at is the way science and math are taught, looking at other ways to teach classes, rather than read the chapter, do the questions at the end of the chapter.
- We are looking at, meaningful learning. That has taken us two years to get progress since many people teach as they were taught. So real reform is in the critical thinking, the problem solving and how difficult it is for a teacher not to give an answer and to get the kids to find the answers and investigate. That's what we have seen over the two years.
- We are not there yet, but at least we are on the way. The hardest part is to change the way we instruct. The kids will pick it up right away (inquiry, problem solving, critical thinking).

Middle School Principal Comments

- I think there are some places where teachers are still teaching the old-fashioned way.
- I think teachers have to teach students to think. The word problems are harder, but the teachers have to teach them to do them. That is the one thing I am seeing more of, especially those teachers involved in the linked learning project.
- As far as implementation, we are getting there. With the help of our MSRT we will continue to grow. I see a shift in teaching methods because the MSRT is helping teachers to overcome their fear of doing something different. Change can be difficult for people.

High School Principal Comments

- I think that we should have more hands-on type instruction, more project-based work. Most teachers are headed in that direction, but some teachers are still involved in direct instruction. We find that if we are doing more projects, and students are doing more hands-on, students get a much better feel and I think a much better understanding. That is were my vision is set, teachers becoming more facilitators and students becoming more involved in their own learning.
- The vision is not well implemented because we have not done enough staff development. You just can't say one day, "this is how it will be done" and then expect them to do it.

The principals were also asked to describe the vision for science teaching and learning within their schools and to comment on the implementation of this vision. The responses to this question mirrored the responses for the question regarding the vision for mathematics. Across schools, multiple teaching methods and teaching students to think and reason in science were cited as the most important aspect of the vision for science within their schools. Most principals felt they were well on their way to implementation of their vision for the science program. Some of the principal comments reading science instruction are shown in Figure 9.

Figure 9. Principal Comments Regarding Science Instruction

Elementary School Principal Comments

- I think the whole district is beginning to focus on what the curriculum should look like and that's critical. We should have a curriculum that mirrors the district and the standards.
- I think it should be hands-on, real world experiences. I want them to teach things that kids can use, things they understand and I have some excellent teachers doing that.
- I have given teachers the equipment and I am giving them the time. If they need training, I will give them the training. I want to take down all of the obstacles for them.
- In some rooms science instruction is a strength and not in others. There is a core group of teachers that can do it and they will be the next generation of the people that will move this thing forward. Now instead of one person, the

MSRT, we will have many people, core teachers who can work on implementing this reform now. That is the change process.

Middle School Principal Comments

- Science should be taught with scientific method and hands-on projects. If they know how to get an answer then they will be learning.
- We still have a way to go. I have a lot of people who are working on their teaching, and they complain about the people who aren't working on theirs. They say "they aren't earning their money."
- We want the project-based learning. Children enjoy projects, having something that's relevant to their everyday lives. What is beautiful is that with the MSRT we are moving closer to increasing and integrating projects in science and math.

High School Principal Comments

- The majority of the science teachers teach project-based and the kids really like that. A lot of times the teachers demonstrate the project and call me to watch them.
- I would say that it is pretty well implemented, about 75% of the science teachers teach that way. But basically, I would say it because most of the science teachers are new and they are coming out with that philosophy.

Leadership for Mathematics and Science

The principals were asked to comment on who provided the leadership for mathematics and science in their schools. Leadership for mathematics and science varied across the schools as shown in Table 8. Some principals noted that leadership came from more than one source. In some schools, the principals reported that the shared decision-making councils provided the leadership. In other schools, the leadership was provided by teachers or shared among the teachers and the principal. Some principals also indicated that the district provided the leadership for mathematics and science. Some of the principal comments are shown in Figure 10.

Table 8. Leadership for Mathematics and Science from Principal Perspectives

	n	Shared Decision Making Council	Teachers	Teachers and Principal	District	MSRT
All Schools	12	25.0%	25.0%	16.7%	25.0 %	8.3%

Figure 10. Principal Comments Regarding Leadership for Mathematics and Science

Elementary School Principal Comments

- I would say that the vision for math and science is set together. I think everyone sees that this is important and we are in this together.
- I think that we have a core group of teachers who are the leaders.
- I would say that we are collaborative, but I would say that the MSRT really brought us a vision of what this reform should look like.
- I think that it is coming from the district as well.
- We are at a crossroads right now and it is time for me to get the hammer out. Those who are not on board will be asked to make some other choices of where they would like to teach because this is where this train is going now.

Middle School Principal Comments

- I think the vision right now is from the district and the WSAS. I think those are the two driving forces that everybody is trying to align with. Our teachers take those proficiencies and benchmarks very seriously. WSAS is taken very seriously as well.
- We have a lot of community members on our shared decision making group - from clergy to business, to a retired person and parents. They form a vision for this school and where this school should be going.

High School Principal Comments

- I would say the vision basically comes from the teacher and working with the principal. I do a lot of talking and working with the teachers as a team.
- We have a shared decision making council of parents and business partners. We do get some involvement, but not as much as we like.
- I would say the district is going in the right direction. We are starting to emphasize some of the things at an earlier grade. We are starting to see some benchmarks coming.

Collaboration Among Teachers

The principals were asked to describe the opportunities for teachers to discuss and examine the mathematics or science curriculum and work together to understand and implement it. Elementary school principals reported the teachers were given opportunities on banking days (no student attendance days that occur about once a month) and during in-services to discuss mathematics and science. Some elementary principals reported creative meeting times such as Saturday activities set up for the teachers by the MSRT. Another creative meeting time was structured as a support group for teachers piloting the new mathematics curriculum. Middle school principals reported that the teachers have a common grade level team planning time or that teachers hold special cross-grade meetings about once a month to discuss mathematics and science. In the high school, department chairs were beginning to meet to examine expectations for students across the curriculum, not just in mathematics and science. Some of the principal comments are shown in Figure 11.

Figure 11. Principal Comments Regarding Collaboration for Mathematics and Science

Elementary School Principal Comments

- We have been using Banking Time days and more grade level meetings.
- We are doing some across grade level meetings and every once in a while we will do an above and below check to see where they are going.
- We have grade level meetings where I have provided substitutes for them.
- We have had some Saturday activities and some after school things that our MSRT did.
- The MSRT wrote an Eisenhower grant so that people using Investigations have the opportunity to get together and they have formed an Investigations support group.

Middle School Principal Comments

- The MSRT has been holding meetings once a month to talk about math and science.
- They meet across grade levels.
- I find out what the teachers are thinking through the MSRT and how I can better support them.

High School Principal Comments

- They have been meeting with department chairs. The chairs have not only talked to teachers, but have started to talk more about what should be happening with kids with other departments like the guidance counselors and data processing.
- What we are trying to do is to get all teachers to talk more across all departments. We are meeting over the summer to discuss how some of these project-based learning opportunities can be used in math, science, English, and social studies.

Summary

It was evident that the principals showed a great deal of enthusiasm for the Milwaukee Urban Systemic Initiative and the MSRTs' work within their schools. Some indicated that they looked to the MSRTs for expertise and commented that the MSRT provided a new energy within the schools. Some principals also noted a new found excitement of students with mathematics and science in their schools. The most common concern expressed by the principals centered on their schools' two-year term as a targeted MUSI school coming to an end. The principals said over and over that two years was not enough time to institutionalize change and that the MSRT should be made a permanent part of a school's staff.

One common quest that emerged from the principals centered around the need to teach children to think critically in mathematics and science. The principals at the elementary and middle school levels show

a great deal of excitement when they talked about new curricula, such as *Investigations in Number, Data, and Space* and *Connected Mathematics* and the use of more inquiry-based projects in science as the tools for nurturing critical thinking skills in their students. They were also realistic concerning the level of commitment and training needed to maintain the excitement as well as quality.

The principals acknowledged that teachers need time to collaborate specifically on mathematics and science, but this often can not be accomplished during the school day except for the monthly banking time days. Some of the principals did indicate ways of allowing collaboration among their teachers, but this often involved teachers meeting before or after the regular school day. The principals did note that there was little to no time for the entire school to meet and discuss the vision and implementation for mathematics and science instruction.

Student Voices

Students are the focal point of mathematics and science reform in the Urban Systemic Initiatives program. It is their achievement and abilities that we are working toward improving. However, the voices of students are not considered often enough as we examine the teaching and learning of mathematics and science. Student voices in this study provided a unique perspective on the teaching and learning of mathematics and science as the recipients of reform efforts. Their voices will be heard first for mathematics instruction and then for science instruction.

Mathematics Instruction

The student interviews began with brainstorming their reactions to the phrase "Math Class." As shown in Table 9, students reactions varied. The most frequent response from the elementary school students involved the operations—adding, subtracting, multiplying, and dividing. Some of the elementary school students reported that they loved math class, one noted that math was fun sometimes, and a few said they thought about problem solving and thinking. Several middle school students also thought about operations, but even more reported that math was fun and that they liked it. A few of the middle school students commented that math was hard, whereas others said it was easy. The high school students through of math as fun, problem solving, equations, and homework. Some of the student comments are shown in Figure 12. For the most part, their comments regarding mathematics were positive.

Table 9. Mathematics Instruction from Student Perspectives

Level	n	Manipulatives	Operations; Numbers	Love Math, Fun	Unhappy about Math; Hard	Problem Solving; Applications	Other
Elementary	24	13%	33%	21%	8%	13%	Misc. 13%
Middle	14	---	29%	36%	21%	15%	---
high	6	---	17%	33%	---	33%	Homework: 17%

Figure 12. Student Comments Regarding Mathematics Instruction

Elementary School Student Comments

- I think of problem solving.
- I think of pencil and paper.
- I hate fractions.
- I think of take-away a lot. If you have those little cubes and if you have to take them away.
- I think of using things to help us learn like blocks and stuff.

- I think of division.
- Addition and subtraction.
- I think of times tables.

Middle School Student Comments

- It's important but it depends on what we are learning. Right now we are learning algebra and it's not practical.
- I think algebra is very useful in life, like learning to plot graphs. It depends on what career you're going into and how much it's going to be part of your life.
- I think it is a lot of hard work.
- The work is pretty easy. I get it done pretty fast.
- Word problems, some are easy, some are hard.
- I think it's fun because they teach us in a fun way.

High School Student Comments

- Algebra is fun.
- The history and theories are good.
- The teacher ties it to real life.
- Problem solving comes to my mind.
- Numbers, equations.
- Homework.

Students were also asked to pretend that they were in control of their mathematics class while remaining a student in the class. The students then described what they would be doing, what the teacher would be doing, what topics they would study, what types of activities they would be doing, and to comment on how this differs from what typically happens in their math classes. Table 10 gives a summary of how students responded to the various aspects of the questions that were posed. As students thought about their ideal mathematics class, most indicated that they wanted more connections and discussions about the importance of mathematics in their futures and in their lives in general. Some students at all grade levels also reported wanting more excitement in their mathematics classes. The middle school students wanted mathematics related to the real world, while high school students sought validation for their study of mathematics. Both elementary and middle school students indicated a strong desire to have more help from their teachers in mathematics. Some of the student comments are shown in Figure 13.

Table 10. Ideal Mathematics Class from Student Perspectives

Level	n	Student Actions	Teacher Actions	Topics of Study	Activities	Differences
Elementary	26	• Self-learners • Ask questions	• Help students • Explain things • Give ideas • Make sure students understand	• Fractions • Algebra	• Worksheets • Games • Write on board • Work in groups • Work alone	• Less sleeping and more learning • More challenging
Middle	13	• Do real world things • Use computers • No hard problems • No tests • No homework	• Help students • Explain more • Give interesting work • Go step-by-step	• Doing surveys • Alternate ways to solve problems • No fractions, algebra, story problems	• Group work • Hands-on work • Do problems • Build things	• Teachers are boring now • Teachers don't help much now • Different topics, not same old stuff
High	15	• Study theorems • Do one problem a day	• Review homework • Real world • Motivate students • Use games	• Basics first, then harder problems • Theorems • Exponents	• Games • Show films • Worksheets	• Math would be relevant • Would be more minorities in advanced classes

Figure 13. Student Comments Regarding Ideal Mathematics Class

Elementary School Student Comments

- I would make sure all of the kids know how to do everything.
- The teacher would be helping us work with cubes and give us problems.
- I would make it a little more complicated because kids finish early and goof off.
- We would be doing fun stuff like work sheets or games.
- I would rather that everyone work by themselves because that's how you learn better.
- Groups are more fun because you get things done faster.
- If the kids didn't know something, the kids could raise their hands and if they still didn't get if after the teacher explained it, she would help them.
- The teacher would be demonstrating how to do stuff.

Middle School Student Comments

- In an ideal math class we would be doing problems and surveys.
- We would be doing computers.
- We would be doing stuff in business like checkbooks, stuff in the real world.
- There would be no hard problems, no hard fractions, no algebra, and no story problems.
- There would be different stuff everyday instead of going over the same old stuff.
- I would go over the things step-by-step with students.
- I would like to use math to build things like buildings.

High School Student Comments

- Teaching like what is supposed to be taught like through games.
- I would like to see the way math relates to the real world. My teacher would show us all of the jobs that rely on math skills and how it will apply to college.
- Our teacher showed us films on how calculus was applied in the real world, like in the building of dams. My other classes were not like that. They were usually 2000 year old rules with no showing of their real life application.
- If I would be teaching I would make the students want to be there. Just standing in front of the room with a book, that's a waste of time. It makes it look like these teachers don't know what they are doing. Just relaying the answers from a book is not learning.
- I like the way our class is designed now, but there are not a lot of minorities in AP classes. Teachers don't tell students how much farther they will go if they take more math. They don't tell them what it will do for them. I really hate it since I am the only black left in my class. You usually see very few minorities in math classes.

Science Instruction

The students brainstormed their reactions to the phrase "Science Class." Table 11 shows that elementary and middle school students were more positive about science class than were high school students. Most elementary and middle school students responded that science was fun and involved hands-on learning. In contrast, more than half of the responses from high school students indicated that science was boring and that they wanted more challenging material and experiences in their science classes. Some of the student comments are shown in Figure 14.

Table 11. Science Instruction from Student Perspectives

Level	n	Hands-on	Fun, Cool	Easy; Not Challenging	Boring
Elementary	26	53%	41%	—	6%
Middle	13	63%	19%	13%	6%
High	15	38%	—	25%	38%

Figure 14. Student Comments Regarding Science Instruction

Elementary School Student Comments

- I think of experiments.
- Right now we are learning about pollution and we are building things out of stuff like bottles and straws.
- We do a lot of studying about microscopes where we look at our hair and stuff.

- I think of mixing chemicals and putting markers in water.
- Science is fun. I think of minerals.
- We do more fun stuff in science than in English or reading. We do more stuff with our hands.
- I like science.
- It is cool.

Middle School Student Comments

- Experiments come to mind.
- Science is okay. We do experiments like volcanoes, making biomes, making animals.
- I like it because we look at nature and stuff and dissect things.
- In our science class we are doing a lot of experiments and learning how different chemicals interact.
- I like science class because we do experiments and I like to learn by having fun.

High School Student Comments

- I liked environmental science because it was hands-on with field trips.
- Dissecting, chemistry - like blowing up things and the periodic table.
- It's boring. The teacher is good but doesn't tie it to my life.
- Boring. They don't teach us much that we really need.
- They don't teach you anything. They just review and don't teach you anything you need to know.
- I don't feel challenged.

The students were then asked to pretend that they were in control of their science class. They were to describe student actions, teacher actions, topics of study, and types of activities in their ideal science class. They were also to explain how their ideas differ from what typically happens in their science class. Table 12 gives samples of how students responded to the various aspects of the questions that were posed at each level. As students thought about their ideal science class, almost all students indicated that they would have more hands-on experiences such as conducting experiments and going on field trips. Many students had definite ideas about topics they would like to study such as astronomy, chemistry, animals, and nature. Students at all levels noted that the teachers would help students more to understand what was being studied. At the middle school level, some students commented that they would not do worksheets, read and answer questions, or do busy work. Some high school students also said they would have no lectures or worksheets. The middle school students wanted to take many more field trips and the high school students want to do more projects and group projects. Some of the student comments are shown in Figure 15.

Table 12. Ideal Science Class from Student Perspectives

Level	n	Student Actions	Teacher Actions	Topics of Study	Activities	Differences
Elementary	22	• Do experiments • Go on field trips • Build things	• Tell students to solve problems	• Dinosaurs • Oceans • Chemistry • Astronomy • Fossils	• Hands on work • Experiments • Research • Use computers	• More student directed work • More hands-on • More field trips
Middle	24	• Hands on • Experiments • Go outside	• Help students • Break things down for students • Explain more	• Nature • Oceans • Chemistry • Animals	• Hands-on work • Experiments • Make commercials • Make posters • Field trips	• Out of book now • No challenge now • Just watch movies • More hands on • More field trips
High	13	• More hands on • Chemistry • More challenge • More real world	• Helping students • Demonstrate	• Chemistry • Astronomy • How things are created	• More group work • More projects	• No worksheets • No lectures • More hands-on • More challenge

Figure 15. Student Comments Regarding Ideal Science Class

Elementary School Student Comments

- We would do an experiment, then write down our observations about it.
- For science I would say less writing and more experiments.
- We would study dinosaurs and go to someplace in the city to do experiments.
- We would be learning about astronomy.
- I would like to study from the encyclopedia and learn a little bit about what you don't know.
- If people liked different stuff, I think that they could do things that they like with experiments.
- The kids could build things however they want, not like the teacher wants.

Middle School Student Comments

- For science, we would be doing chemistry.
- We would be doing hands-on experiments.
- Teachers should break things down so we can understand them.
- I would like to learn more about the ocean.
- I would like to learn more about nature
- Right now we just do things out of the book that don't teach you anything. It's just busy work.
- We watch movies now and correct each other's papers. I don't really like doing it, but it's okay, but we do the same thing over and over again.
- I would like to go on a field trip to a forest or a lake and talk about nature and trees and that.
- I would take them to the zoo to study animals.

High School Student Comments

- If I was to design a class I would like more hands-on things.
- I would have more challenging things, more real world applications and more hands-on.
- I would be working with chemicals.
- I would like to do more projects.
- In science there would be no lectures.
- I would not give so many worksheets because all classes give out worksheets.
- I would like to learn about the stars.

Summary

What appeared overwhelmingly was that students enjoyed mathematics and science more and applied themselves more if they were challenged. For the students interviewed, the challenge went beyond a time limit or a grade for a project. The challenge the students desired was to apply critical thinking and conduct creative, problem-solving projects. The other area that emerged was the students' desire to see the relevance in what they were being asked to accomplish. They wanted the projects or assignments related to their home culture and their future. It will become evident from the discussion of the classroom observations that this was found to be a major deficit in almost all classrooms.

Observations of Classroom Practice

A rubric was used applied to the notes from each observation of classroom practice. The rubric (located in Appendix D) focused on three areas: (1) standards-based instruction, (2) equity, and (3) community of learners. Each area is further differentiated into two or three components. The rubric provides for specific behavioral observations of each lesson and a teacher's journey to standards-based instruction. The observations have been aggregated by level and discipline. A mean rating for each component is given for each level—elementary, middle, and high—along with the percentage of classroom observations falling within each rating category.

Standards-based Instruction

Standards-based teaching in mathematics for the purposes of this study was defined by the National Council of Teachers of Mathematics (1989, 1991) standards documents on curriculum and teaching. The science standards developed by the National Research Council (1996) were used to define standards-based teaching in science. Evidence of standards-based teaching was evaluated through three components: (1) inquiry, (2) content rich, and (3) teacher questioning.

Inquiry. The focus on inquiry as a framework for constructing lessons and curricula is at the heart of standards-based instruction. The rubric examines investigation and problem solving, use of materials and tools, and student explanations based on their observations as components of inquiry. The results for inquiry are shown in Table 13. The overall mean rating for all levels and both disciplines was 2.84. The highest rating for inquiry was 3.36 in elementary school science. The lowest rating was 2.20 in middle school science.

Table 13. Observations: Inquiry Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	31.3%	12.5%	18.8%	18.8%	18.8%	2.80
Middle	9	22.2%	11.1%	33.3%	11.11%	22.2%	2.80
High	6	16.7%	16.7%	16.7%	33.3%	16.7%	2.89
Science							
Elementary	14	0%	28.6%	28.6%	21.4%	21.4%	3.36
Middle	10	30.0%	30.0%	10.0%	0%	20.0%	2.20
High	7	42.9%	14.2%	0%	0%	42.9%	2.85
Overall Rating	**62**						**2.84**

The NCTM recommended strategies and approaches for inquiry-based instruction were evident in only a small portion of the observed mathematics lessons. The observations that were rated low relied on rote activities, the discouragement of exploring anything but the "right" answer, and only allowing the students to use materials or technology according to teacher directions. Those classroom teachers approaching or accomplishing inquiry-based mathematics instruction employed techniques such as probing and pushing students for their justification and explanation of the path taken to their solutions, allowing students to explore alternative paths, and allowing students to share their strategies amongst themselves. In the classrooms where inquiry-based instruction was accomplished, the observers consistently reported that levels of student engagement were high and behavior problems were low.

The majority of the science classroom observations that rated low involved rote or pencil and paper work and allowed for little or no inquiry. Simply recording information or recalling facts did not provide a context for students to engage in inquiry. The observers also noted that the curiosity of students working with materials or equipment was discouraged in these classrooms. The teachers stressed only one way or the "correct" way to use the materials and equipment. The higher inquiry ratings reflected science lessons in which students were defending their conjectures and assuming responsibility for their own learning. Teachers allowed students to explore various and alternative methods of using materials and equipment

and allowed students to develop strategies for solving their own problems. These teachers also encouraged and allowed discussions among the students.

Content Rich. To be considered standards-based instruction, the lesson must be rich in content. Each lesson was examined to determine whether or not it was content rich. The content richness of each lesson was rated by observing the degree to which the students' understanding of a topic or concept was taken. For example, was this content superficial or at a low level of challenge or has challenging, new information been presented. Content richness was also determined by observing the degree to which connections were made with other concepts within the discipline, to another discipline, or to real world examples. The results for content rich are shown in Table 14. The overall mean rating for all levels and both disciplines was 2.80. The highest rating for content rich was 3.33 in high school mathematics. The lowest rating was 2.20 in middle school science.

Table 14. Observations: Content Rich Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	25.0%	12.5%	18.8%	37.5%	6.3%	2.87
Middle	9	22.0%	22.0%	33.0%	0%	22.0%	2.77
High	6	17.0%	17.0%	17.0%	17.0%	33.0%	3.33
Science							
Elementary	14	7.2%	43.0%	14.2%	21.4%	14.2%	2.93
Middle	10	30.0%	30.0%	10.0%	0%	20.0%	2.20
High	7	42.9%	14.2%	0%	0%	42.9%	2.86
Overall Rating	**62**						**2.80**

In those mathematics or science lessons that rated low on content rich, problems appeared in the implementation of the lesson or in the design of the lesson. Also included were rote lessons that simply had students fill-in-the-blank or find one solution in one way. It was often noted by various observers that teachers were only interested in the "correct" answer and that no connections were made for the students or by the students regarding the concepts discussed.

Mathematics lessons judged high on being content rich had students using their knowledge to look further into a concept or to apply it to a real world situation. Both of these strategies seemed to assist the student in deepening their conceptual understanding according to the observers as evidenced by the connections students made among themselves or as an entire class. In these lessons, students were able to demonstrate through application, discussion, and revision that they were gaining a deeper understanding of the concept or topic being studied.

Science lessons rate high on being content rich had students applying concepts to new situations, making connections from task to task, and challenging previous assumptions. These content rich lessons consistently integrated previously learned concepts, providing multiple activities to understand concepts and applied the scientific method to "real world" problems.

Teacher Questioning. The teacher questioning strategies assessed using this rubric involved observing the level of questions posed from simple explanation to probing for rationale; the degree to which the teacher presses students to extend their thoughts, make comparisons, and justify their answers; and whether the teacher uses errors as method to build on learning or simply ignores errors. The results

for teacher questioning are shown in Table 15. The overall mean rating for all levels and both disciplines was 2.37. The highest rating for teacher questioning was 2.93 in elementary school mathematics. The lowest rating was 1.70 in high school mathematics.

Table 15. Observations: Teacher Questioning Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	25.0%	18.8%	12.5%	25.0%	18.8%	2.93
Middle	9	11.0%	33.0%	22.0%	22.0%	22.0%	2.44
High	6	50.0%	0%	0%	34.0%	16.0%	1.70
Science							
Elementary	14	35.7%	21.4%	14.2%	14.2%	7.1%	2.14
Middle	10	40.0%	10.0%	30.0%	20.0%	0%	2.30
High	7	57.1%	0%	14.2%	28.6%	0%	2.14
Overall Rating	**62**						**2.37**

In those mathematics lessons rating low on teacher questioning, the teachers most often used questioning as a way to redirect attention when a class lost interest in the current task. The teacher questioning observed in multiple lessons was simply to ask for a recall of the steps with no probe as to why the student chose the path they did to their solution. In those mathematics lessons rating high on teacher questioning, the observers noted that the more the teacher pushed the students to explore through their use of questioning, the more the students responded and paid attention to the task.

Teacher questioning strategies in science that rated low focused on students' recall of directions for the task and not the concepts to be discovered from it. There was little or no demonstration through teachers' questions that the concepts being used were important in everyday life. Other teachers used questions as a means to control the classroom and not to further inquiry. Some teachers did not question students' assumptions at all, while others were observed relying heavily on notes and manuals for questions to ask students. Highly rated questioning included asking open-ended questions; pressing and probing students with "why" and "what" questions; asking students to use current knowledge to predict future events; and insisting on application of the lesson's concepts to experience.

Equity in Mathematics and Science Instruction

The observations of classroom practice tried to determine the level of equity within each classroom. Evidence of equity was evaluated through two components: (1) high expectations and (2) cultural connections.

High Expectations. Each lesson was examined for the expectations it held for students. Observers noted the level of engagement the students exhibited and the level to which the teacher required and insisted the students be engaged in the task. They also observed the level to which the teacher demonstrated to the students that student ideas were valued and students were capable of achieving and understanding the content of study. Finally, the observers also noted the participation of students across cultural and gender groups. The results for high expectations of students are shown in Table 16. The overall mean rating for all levels and both disciplines was 2.79. The highest rating for high expectations of students was 3.44 in middle school mathematics. The lowest rating was 1.85 in high school science.

Table 16. Observations: High Expectations Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Ratings
Mathematics							
Elementary	16	12.5%	25.0%	25.0%	18.8%	12.5%	2.69
Middle	9	0%	11.0%	44.0%	34.0%	11.0%	3.44
High	6	34.0%	0%	17.0%	17.0%	33.0%	3.33
Science							
Elementary	14	14.2%	14.2%	43.0%	7.1%	21.4%	2.92
Middle	10	30.0%	20.0%	30.0%	10.0%	10.0%	2.50
High	7	71.4%	0%	0%	28.6%	0%	1.85
Overall Rating	**62**						**2.79**

In the mathematics or science lessons rating low on expectations for students, a common behaviors exhibited by the teachers was a physical separation from the students whether it was sitting behind a desk or not circulating among the students. These teachers also tended to ignore disruptive behavior and did not push for disruptive or off-task students to work on the lesson. Some observers also indicated teachers that made negative judgmental comments to students regarding their ability level of understanding.

The behaviors of the teachers with high expectations for students in mathematics, made several attempts to have all students answer questions. They encouraged the students by telling them that they were all capable of achieving and could all master the task at hand. Overwhelming, the teachers with high ratings physically demonstrated enthusiasm in their constant motion and walking around the room, open and frequent gesturing, vocal variation, and their willingness to "get in" with the students physically. These teachers would work with the students at their desk, table, work station or in close proximity when doing an experiment.

Teachers demonstrating high expectations for their students in science required all students to participate in the lessons by requiring students to summarize and ask questions. These teachers did not accept students' excuses, but pushed the students and told them they were capable. There was also constant reassurance that the students had the knowledge to complete their task even if the students thought otherwise and there was constant reassurance and encouragement from the teachers.

Cultural Connections. When considering whether or not cultural connections were made during a particular lesson the observers noted whether any historical perspectives of gender or cultural groups were included either in the lecture or were evident in the classroom from decor or student projects. The observers also noted whether the lesson was related to students' present day cultural environments or home environments. Finally, they also noted whether or not the teacher challenged cultural or gender stereotypes and biases. The results for cultural connections are shown in Table 17. The overall mean rating for all levels and both disciplines was 1.75. The highest rating for cultural connections was 2.00 in both middle school mathematics and middle school science. The lowest rating was 1.20 in high school science.

As is evident from the results, most of the mathematics and science lessons did not address cultural or historical references nor connect to the students' lives. Some of the lower rated lessons were used outdated materials which required explanation of appliances used in the 1960s; teachers failing to

make natural connections to students' home life; or missing opportunities to point out examples familiar to students.

Table 17. Observations: Cultural Connections Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	56.3%	12.5%	12.5%	6.3%	12.5%	2.06
Middle	9	56.3%	0%	11.1%	0%	34.0%	2.00
High	6	66.0%	17%	0%	0%	17%	1.22
Science							
Elementary	14	78.5%	7.1%	0%	7.1%	7.1%	1.57
Middle	10	70.0%	10.0%	20.0%	0%	10.0%	2.00
High	7	42.9%	42.9%	14.2%	0%	0%	1.20
Overall Rating	**62**						**1.75**

Those lessons that did score high on cultural connections in mathematics related concepts to the students' lives and provided the students with various "real world" examples of the application of the concept. One other finding that the higher rated lessons had in common was that the lessons were hands-on. When students were able to apply their knowledge to real life, work, or even the use of ancient tools for their work, the observers all indicated that the lessons were successful in connecting with home culture and academic traditions.

In science, the few lessons that rated higher on cultural connections allowed the students to experiment with familiar materials and asked them how they have seen those materials used at home. This provided an easy avenue for the teacher to prompt the students to explore alternate uses of materials and methods of discovery.

Community of Learners within Classrooms

The observations of classroom practice examined whether a community of learners existed within each classroom. Evidence of a classroom community of learners was evaluated through three components: (1) interactions, (2) intellectual engagement, and (3) source of knowledge.

Interactions. A major element in becoming a classroom community of learners is the level and type of interactions among the students. The observers noted the degree to which the students were engaged in collaborative working relationships. They also examined the essence of student interactions by noting whether the students were involved in making sense of mathematical and scientific ideas by trying to understand the validity of alternative approaches, answers, and observations. The results for interactions in the classroom are shown in Table 18. The overall mean rating for all levels and both disciplines was 2.66. The highest rating for interactions in the classroom was 3.00 in high school science. The lowest rating was 1.55 in high school mathematics.

Table 18. Observations: Interactions Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	25.0%	18.8%	18.8%	12.5%	25.0%	2.93
Middle	9	22.2%	33.3%	22.2%	22.2%	0%	2.44
High	6	50.0%	16.7%	0%	16.7%	16.7%	1.55
Science							
Elementary	14	14.2%	35.7%	14.2%	14.2%	21.4%	2.93

Middle	10	20.0%	50.0%	10.0%	0%	20.0%	2.50
High	7	42.9%	14.2%	14.2%	0%	28.6%	3.00
Overall Rating	**62**						**2.66**

In the lower rated mathematics and science lessons on interactions, students worked independently with no encouragement for interaction among students. Most of these lessons were very teacher directed and allowed no room for student exploration. The observers noted that in these lower ranked lessons the students also seemed very frustrated, were inattentive to the teacher, frequently off-task, or were disruptive. The interaction among students was stifled in these lessons as students were told to work alone and the task was very teacher directed.

In the higher rated mathematics lessons on interactions, collaboration and sharing among the students was very apparent. The teachers encouraged the students to seek out each other for answers and support. The observers noted that in these observations, the students provided encouragement for each other and also monitored each other's behavior and brought off-task students back into their work.

In the higher rated science lessons, observers noted students were sharing problem-solving strategies and relying on each other for help before going to the teacher. Observers rated classrooms high in interaction consistently commented that the students demonstrated a high level of excitement about the task or project they were engaged in and an eagerness to explore.

Intellectual Engagement. When students are intellectually challenged, it is more likely that they will form a community of learners. The observers noted whether the students were challenged intellectually with important mathematical and scientific ideas throughout the lessons. They also noted the level of involvement of students in discussing issues and being consistently involved, excited, and interested in the examination of the ideas. The results for intellectual engagement during the lesson are shown in Table 19. The overall mean rating for all levels and both disciplines was 2.98. The highest rating for intellectual engagement during the lesson was 3.33 in both middle school and high school mathematics. The lowest rating was 2.71 in both elementary and high school science.

Table 19. Observations: Intellectual Engagement Ratings

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	6.3%	31.3%	18.8%	31.3%	12.5%	3.12
Middle	9	0%	11.1%	55.6%	22.2%	11.1%	3.33
High	6	0%	33.3%	16.7%	33.3%	16.7%	3.33
Science							
Elementary	14	21.4%	14.2%	28.6%	28.6%	7.1%	2.71
Middle	10	10.0%	70.0%	10.0%	0%	20.0%	2.80
High	7	28.6%	28.6%	14.2%	0%	28.6%	2.71
Overall Rating	**62**						**2.98**

In the lower rated mathematics and science lessons on intellectual engagement, students were visibly disengaged and involved in off-task discussions, agitation, boredom, and even sleeping. Some of the issues the observers indicated were an emphasis on rote strategies, confusing directions, rote activities, below grade level tasks, or lessons that were too complicated for the grade level. Observers noted that potential intellectual engagement was cut-off in several classrooms when student questions were not allowed or students were expected to be compliant and not explore.

The higher rated mathematics lessons on intellectual engagement successfully engaged most or all students engaged in the lesson. The strategies these teachers used included requiring students to prove their answers in terms of the concepts under study, allowing students to create and explore the parameters of their assignments, and a high level of sharing of strategies among the students. The observers reported that in the higher rated science lessons on intellectual engagement classrooms the students were excited about their tasks. These students could be seen challenging each other with important ideas and facilitating their own learning through exchanges. During a lecture in one class which rated highly on intellectual engage, students were allowed to become part of the lecture by contributing their knowledge to the teacher's presentation.

Source of Knowledge. In forming a classroom community of learners, the students need to realize that they can and should be their own source of knowledge. The observers noted the degree to which the teacher recognized the students as a source of knowledge or whether the teacher or a textbook was the source of information and ideas. They also examined the degree to which the teacher provided the students with opportunities to be their own source of knowledge as demonstrated by encouraging the students and letting them know their ideas were valued. Finally, the observers indicated where the authority resided in the classroom. For example, did the students or the teacher decide what knowledge was valuable and correct. The results for the source of knowledge during a lesson are shown in Table 20. The overall mean rating for all levels and both disciplines was 2.77. The highest rating for the source of knowledge during a lesson was 3.14 in elementary school science. The lowest rating was 2.16 in high school mathematics.

Table 20. School Mathematics Observations: Source of Knowledge

	n	1 (low)	2	3	4	5 (high)	Mean Rating
Mathematics							
Elementary	16	25.0%	12.5%	31.3%	12.5%	18.8%	2.87
Middle	9	11.1%	55.6%	0%	11.1%	22.2%	2.44
High	6	33.3%	33.3%	16.7%	16.7%	0%	2.16
Science							
Elementary	14	14.2%	14.2%	43.0%	14.2%	21.4%	3.14
Middle	10	20.0%	30.0%	30.0%	0%	20.0%	2.70
High	7	42.9%	14.2%	28.6%	0%	28.6%	2.86
Overall Rating	**62**						**2.77**

The mathematics and science lessons that rated low on source of knowledge often emphasized only the "correct" answers to questions. These teachers either discouraged or ignored answers they felt were not "correct." Most of the lessons were very teacher directed with no opportunities provided for the students to explore outside the directions given for the task. The students were not allowed to "go out of the lines" when answering questions. In some cases, the lessons were poorly planned or executed and when the students tried to seek clarification, they were told to listen more carefully. The lessons that were rated low were very teacher directed, did not encourage student ideas, required students merely to follow directions, and employed only one response questioning methods.

The mathematics lessons that rated high on source of knowledge, the teachers moved around the room and questioned, pressed, probed, and challenged students to extent their thinking. These teachers

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showed genuine excitement over the students' discoveries and interest into how they arrived at their answers. This in turn had the students sharing their work with each other enthusiastically and willingly. These teachers also allowed students to direct and define some of their own work.

The science lessons that rated high on source of knowledge considered students to be a source of knowledge. The observers saw the teachers encouraging students to build on each other's findings and allowing student ideas to take center stage. For example, in one observation, students were required to lead and run parts of the class. The observers also noted that in some classes, students were holding philosophical and ethical conversations with teachers regarding advanced scientific methods and concepts in which the teacher valued and acknowledged the students positions and thoughts.

Summary

The observations of classroom practice showed that much instruction in mathematics and science was not standards-based. However, at all levels in both disciplines there were some strong examples of standards-based instruction. Often a dichotomy seemed to appear, especially in high school science and sometimes in high school mathematics. It seemed as though either the observed lessons were strongly standards-based or not at all. The overall ratings for each component of standards-based instruction were 2.84 for inquiry, 2.80 for content rich, and 2.37 for teacher questioning.

The observations of equity in classroom practice showed that teachers, in general, have moderate expectations (rating of 2.79) of students in mathematics and science. However, the expectations of students is very low in high school science and fairly low in middle school science. The existence of cultural connections in the observed lessons was very low (overall mean rating of 1.75) at all grade levels in both disciplines. In most lessons, it was non-existent.

The existence of classroom communities of learners was moderate. Interactions among students were noted more frequently in the observed elementary and middle school lessons than in the high school lessons. Students appeared to be more intellectually challenged in mathematics than in science. In general, students were not often viewed as a source of knowledge across the levels or disciplines. However, there were strong examples of students as a source of knowledge, but not in high school mathematics. The overall ratings for each component of community of learners were 2.66 for interactions, 2.98 for intellectual engagement, and 2.77 for source of knowledge.

Conclusions

Listening to the voices of those engaged in reform efforts clarifies what participants see as successes and challenges. This study provide a glimpse into what participants see as critical components and resources needed in the day-to-day implementation of a reform effort. The methods used and the information gathered from this type of study can assist in the design and evaluation of future reform efforts.

What has been the impact of MUSI?

At the elementary and middle school levels, MUSI has made some notable impact from the perspectives of teachers, principals, and students. However, this impact still seems to be in its infancy and is only beginning to take hold. Any impact at the high school level is questionable.

The principals at all levels were very appreciative of the Milwaukee Urban Systemic Initiative and gave the impression that it was making a big difference in their schools. Teachers at the elementary and middle school levels, in general agreed with the principals but not as emphatically, noting that MUSI had helped their schools move towards improvement of mathematics and science teaching and learning. In contrast, three-fourths of the high school teachers indicated that for the most part, MUSI was not impacting their mathematics and science programs.

In particular, elementary and middle school teachers noted that MUSI had helped them improve their teaching of mathematics and science and had helped them move towards standards-based instruction. Some also expressed their own renewed enthusiasm in teaching mathematics and science and noted that students were placing an increased value on these subjects as well. The impetus for this growth and change seemed to result from two sources—mainly from the support provided by the Mathematics/Science Resource Teachers (MSRT) and some from the participation in university courses. At the elementary school level, almost all teachers remarked that the MSRTs provided them with much assistance throughout the year. At the middle school level, about half of the teachers said they received some assistance and about half said they received much assistance from the MSRTs. Even some of the high school teachers (30 percent) acknowledged that the MSRTs had provided them with some assistance in mathematics and science. The teachers noted that MSRTs were available to model lessons, provide feedback on teaching performance, find materials and resources, and just talk with you about mathematics and science teaching and curriculum.

Much of the impact of MUSI seemed to rest upon the shoulders of the MSRT. When talking about MUSI, the conversations with teachers and with principals focused on the work of the MSRT within their schools. Some references were made to the opportunities for teachers to participate in university courses, but for the most part few or no other references were made to MUSI activities or efforts. Other evidence of the limited scope of the initiative from the perspectives of both teachers and principals is the concern over losing their MSRT when their two years of being a targeted school ends. Several noted that the MSRT brought more focus and attention to mathematics and science in their schools and kept their staffs on track. This raises the issue of what policies and practices, as well as expectations, could be established at the school level and the district level through the systemic initiative to ensure continued attention on improving mathematics and science that would not be dependent upon the placement of a Mathematics/Science Resource Teacher in each school.

Is the teaching of mathematics and science standards-based?

Mean ratings across the observations of classroom practice indicated only a moderate to low implementation of standards-based instruction. The observations of classroom practice found the existence

of standards-based instruction in both mathematics and science at all levels. This is supported by the students' responses as they talked about their learning of mathematics and science. Thus, there appears to be movement towards or at least awareness of standards-based mathematics and science teaching.

Fifty-five percent of the high school teachers reported that no or little instruction was standards-based. This perspective was well aligned with the observations of practice. All middle school teachers and 80 percent of the elementary school teachers reported that some or most instruction was standards-based. This was higher than was observed. Principals at all levels portrayed their schools at a much higher level of implementation of standards-based mathematics and science teaching than was noted in observations of classroom practice or in the responses of the teachers.

From the observations of classroom practice, the excitement of students towards learning was clearly evident in classrooms with standards-based instruction as contrasted with the lack of excitement and the noted "boredom" among students in classrooms with traditional instruction. The student interviews revealed an excitement and interest among the students as they talked about their ideal mathematics and science classes which would clearly be standards-based. Students expressed that they wanted their mathematics and science learning to be more challenging, to examine different topics, and to not be the same old stuff. They wanted more intellectual engagement. The observers noted that when students were intellectually challenged, they responded favorably based on their high levels of engagement in the lessons. Students also noted that they wanted mathematics and science to be more relevant by connecting it to their current lives and their futures. The lack of cultural connections to students' lives was very apparent in the observed lessons. Students wanted opportunities to do more student-directed work and projects, pose their own questions to study, and be able to use their own ideas on how to approach problems. In essence, they wanted to be respected and valued as a source of knowledge. The students, however, also expected their teachers to explain things to them and help them understand mathematical and scientific ideas.

What leadership exists within the schools for mathematics and science?

Leadership did not seem to exist within some schools for mathematics and science. At both the middle and high school levels, some teachers indicated that no one in their school provided such leadership. In the other schools, both the teachers and principals identified individuals that were providing leadership for mathematics and science. These individuals included teachers, implementors, department chairs, MSRTs, and principals. About one fourth of the principals also noted that leadership for mathematics and science came from the Shared Decision Making council in their school or from the district. These centers for leadership were not mentioned by the teachers, thus indicating teachers did not view the school council or the district as providing leadership for their school in mathematics and science.

At the elementary level, leadership was often provided by the MSRT or the principal. Teachers and principals indicated that the MSRT had become a central figure in providing leadership and vision for mathematics and science reform. In some of the elementary schools, it seemed that no one had really been providing leadership for mathematics and science before MUSI.

At the middle school level, teachers indicated that leadership for mathematics and science was shared among a group of teachers or with the principal in about one fourth of the schools. In another third of the schools, the teachers reported that leadership was provided by individual teachers. The leadership provided by regular classroom teachers was most apparent at the middle school level. The MSRT supported and assisted these school-based leaders.

In about one fourth of the middle schools and two-thirds of the high schools, teachers noted that no one provided leadership for mathematics and science. The teachers explained that each person just did what he or she felt they were expected to do. It was surprising and disconcerting to hear teachers from schools involved in systemic reform in mathematics and science that no one was providing leadership within their schools for these subject areas.

What opportunities are teachers provided for collaborative examination and discussion of the teaching and learning of mathematics and science?

Opportunities did exist at many schools for teachers to collaboratively examine and discuss the teaching and learning of mathematics. Because of MUSI, there did seem to be an increase in the number of opportunities to meet around issues of mathematics and science at the elementary and middle school levels and that these opportunities often involved the MSRT. However, about one fourth of the elementary teachers and one fourth of the high school teachers stated that they had no such opportunities. When opportunities did occur they were limited and occurred infrequently. Elementary teachers had the fewest opportunities to collaborate around mathematics and science and high school teachers had the most opportunities. Some disparity existed between the principals and teachers in their views regarding the adequacy of time and number of opportunities to collaborate. Principals acknowledged that teachers needed time to meet and talk with each other about mathematics and science, but did not express the need to increase this amount of time as urgently as the teachers.

A typical response from teachers and principals at all levels regarding examples of opportunities to collaborate was the use of Banking Days. These non-student attendance days occur once a month. Some teachers also noted that these are usually filled with numerous issues besides mathematics and science. At one elementary school teachers were able to meet 30 minutes by grade level to focus on mathematics and science. At another school, elementary teachers noted they were able to meet by grade level one day a month after school to talk about mathematics. The teachers at a middle school noted that they meet biweekly to discuss mathematics during the school day and once a month after school. Another middle school noted that it has been very difficult to meet by discipline during the school day, so they are going to try meeting in the morning before school next year. The high school teachers noted that most did not have common planning time but that they met during department meetings and Banking Days, and often had informal conversations with other staff members.

Most teachers in this study felt a strong desire to be allowed time to dialogue with other teachers to better understand the mathematics and science standards, to discover and share strategies for inquiry/problem-solving based instruction, and to look to each other for support and confidence. In

essence, they longed for the establishment of a professional community within their schools. Other researchers of reform efforts report similar results. Kruse, Seashore Louis, and Bryk (1997) suggested that "openness to change; trust and respect; teachers having knowledge and skills; supportive leadership and socialization are critical to the development of a professional community" (p. 6). If teachers are going to move towards standards-based instruction, they will need more opportunities to collaboratively examine and discuss mathematics and science curriculum and students' learning on a regular and frequent basis. It is difficult to know how much time is adequate, but scheduling time into the regular work day of teachers so they can interact weekly or more frequently around mathematics and science seems to be essential.

Summary

In examining the three voices of reform—teachers, principals, and students—and comparing their voices to the observations of classroom practice in mathematics and science, some interesting comparisons occurred. In general, the students' comments and responses were well aligned with the observations of practice. For the most part, they told the same story. The students presented mixed views of mathematics and science learning that ranged from traditional lessons to standards-based lessons. The teachers' responses were not as strongly aligned as the students with the observations, but told fairly similar stories. The principals' responses were not aligned with the observations. For example, they felt that the implementation of standards-based instruction in mathematics and science was much higher than was observed and higher than that reflected upon by the teachers.

The schools examined in this study appear to be making strides in infusing standards-based mathematics and science teaching. Each voice, especially students, expressed a desire to move towards the implementation of standards-based instruction and indicated some understanding of what this would entail. However, only first steps have been taken in this systemic initiative. The observations of classroom practice indicate that many teachers are still using traditional approaches to teaching mathematics and science, but pockets of standards-based teaching were evident at all levels—elementary, middle, and high—and in both mathematics and science.

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Appendix A

Interview Protocol for Teacher Group Interview

1. Collaboration
   Talk about the opportunities you have as teachers to get together to discuss mathematics and science in regards to the curriculum, teaching strategies, and students' learning.

   Probes: *What types of things do you discuss when you have the opportunity? How often?*
   Talk more about opportunities to you have to get together to examine and discuss the math and science curriculum and work together to understand it and implement it?
   What types of things do you do in your school to coordinate the implementation of the MPS science curriculum, e.g. kits or modules, or the MPS mathematics curriculum?
   Do you ever have a chance to observe each other or other teachers in your school?

2. Standards-based Mathematics and Science
   (a) Using a scale from 1 to 10, how would you describe the agreement of your school staff with regards to how mathematics should be taught? Describe how mathematics is taught in this school.

   (b) On a scale from 1 to 10, how would you describe the agreement of your school staff with regards to how science should be taught? Describe how science is taught in this school.

   (c) Would you characterize most of the mathematics and science instruction you described as standards-based (e.g. aligned with national and state standards)? Why or why not?

3. Curriculum/Program
   (a) What mathematics and science curriculum programs or materials are used in this school? Does everyone use the same program materials?

   (b) Talk about the atmosphere in this school for improving the mathematics and science program.
   Probes: *Who provides the leadership? What do they do?*
   Are there opportunities to critique and discuss the current programs?
   How do you work out differences of opinion and identified challenges within the school?

4. High Expectations
   Discuss the level of expectations you feel are set for the students in your school for student learning.
   Probe: *How are the expectations conveyed to students?*
   Do you think most teachers have high or low expectations? Why do you think that?

5. MUSI Impact
   Talk about ways that MUSI related activities have helped you improve your mathematics and science teaching.
   Probe: *What are you doing now that you hadn't done before MUSI?*
   What types of activities have you participated in (e.g. MUSI-UWM courses)?
   If you have had an opportunity to interact with your MSRT, talk about that interaction.

6. Is there anything else you would like to comment on in regards to MUSI?

Appendix B

Interview Protocol for Principal Interview

1. I'd like you to begin by talking about ways in which MUSI has assisted your school in improving its mathematics and science programs.
   Probes: *What would you say is the best part of being a MUSI school?*
   What is the "value-added" that MUSI has brought to your school?

2. Let's talk some more about the of the work of the MSRT (Math/Science Resource Teacher).
   (a) What other types of things has the MSRT done to improve math and science in your school?
   (b) How do you interact with and facilitate the work of the MSRT?

3. What opportunities are there for teachers to discuss and examine the mathematics or science curriculum and work together to understand it and implement it?
   Probes: *Are there opportunities across grade levels as well as by grade level?*
   Are there other formal or informal opportunities to discuss student learning?

4. Where would you say the vision and leadership for mathematics and science is established within your school?
   Probes: *As the principal, do you provide the vision?*
   Does it rest with a core group of teachers and staff within the building?
   Do community members participate in building the vision?
   Does it come from the district?

5. Let's talk more about the vision for mathematics:
   (a) Describe the vision for mathematics teaching and learning within your school.
   Probe: *How is it that teachers should be teaching and students should be learning mathematics?*
   (b) Would you say this vision is well implemented? Why or why not?

6. Now let's talk more about the vision for science:
   (a) Describe the vision for science teaching and learning within your school.
   Probe: *How is it that teachers should be teaching and students should be learning science?*
   (b) Would you say this vision is well implemented? Why or why not?

7. Is there anything else that you would like to tell us about your mathematics and science programs?

8. Is there anything else that you would like comment on in regards to MUSI?

Appendix C

Interview Protocol for Student Group Interview

1. We're going to start out with some brainstorming.
   I am going to show you something and then I'm going to ask you to tell me what came to your mind when you saw that. Ready?
   (Wait a moment, then show the card with "math class" written on it. Pause a moment longer.)

   What did you think of when I showed you **math class**?
   (Be sure to get at least one response from every student. Probe interesting responses.)
   Probes: What do you think? What else comes to mind? What do you mean by that?

2. I'm going to show you something else and then I'm going to again ask you to tell me what comes to your mind when you see this word. Ready?
   (Wait a moment, then show the card with "science class" written on it. Pause a moment longer.)
   What did you think of when I showed you **science class**?
   (Be sure to get at least one response from every student. Probe interesting responses.)
   Probes: What do you think? What else comes to mind? What do you mean by that?

3. I would like you to pretend that you are in control of your **math or science** class. You can decide what is taught and how it is taught. You are still a student in the class, but you make the plans.
   a. What would you be doing in your ideal **math or science** class?
   b. What would your teacher be doing?
   c. What would you study or learn about?
   d. What kinds of activities would you be doing?
   e. How does this differ from what typically happens in your **math** class?

4. Do you think your teachers like **math or science**? How can you tell?

5. Is there anything else you'd like to tell us about your **math or science** classes?

6. Are there any questions that you would like to ask us?

Appendix D

Rubric for Observations of Mathematics and Science Instruction

Standards-based Instruction

Inquiry				
1	2	3	4	5
No investigation or problem solving evident in the lesson. Mostly pencil and paper or lecture with no or very brief explanations.	Lesson is mainly "follow the recipe." Demonstration with materials and tools by teacher or by a few students. No or very little probing for observations or explanations.	Beginnings of investigations or problem solving in the lesson. Materials and tools used by many students but in a prescribed manner only. Some probing for observations and explanations.	Some opportunities for students to explore information in different ways. Available materials and tools used by students with some flexibility. Students make observations, design strategies, construct explanations, but usually for teacher posed questions.	Investigation or problem solving evident throughout the lesson. Wide variety of tools available for students to select from and use flexibly. Students pose questions or conjectures, develop investigations or strategies, use observations to construct explanations, and evaluate approaches and conclusions.
Content Rich				
1	2	3	4	5
Lesson focuses on recalling facts, terms, or procedures. Emphasis on having fun or enjoyment more than deep learning. No evidence that this lesson went beyond recall to making connections in some way for the students.	Lesson focused on acquiring new facts, terms, concepts, or procedures through rote strategies. Some emphasis on comprehension. Students make some comparisons, but mostly restate answers, resulting in superficial or no connections.	Attempts at applying acquired knowledge, concepts, and procedures in new situations. Lesson aids in making weak connections in some way to same or other disciplines or the real world.	Lesson challenges students to examine current conceptions and deepen to understanding of concepts and procedures. Students make observations that prompt them to look for connections within a discipline, to other disciplines, or to the real world.	Lesson deepens students' conceptual understanding by examining, reasoning about, and synthesizing content. Students can explain the content of the task. Students make critical connections within the discipline, as well as with other disciplines or with real world experiences.
Teacher Questioning				
1	2	3	4	5
Teacher is interested only in correct answers; usually goes no further than to ask "what" was the answer seeking no further reflection. Ignores or disregards errors.	Teacher asks how students solved problems, asking them only to recall steps taken as procedural summaries, not an explanation of why. Disregards or simply corrects errors.	Teacher asks why a particular strategy or approach was chosen, seeking an expected response or just accepts response and does not press for a deeper rationale. Acknowledges errors but does not use them to build further learning.	Teacher attempts to dialogue with students by asking probing questions to elicit reasons and solution strategies, and presses students to reflect on their conceptual thinking to strengthen their understanding. Attempts to use errors to build further learning.	Teacher consistently asks students to justify, evaluate, compare, or defend strategies and answers with links to mathematical or scientific reasoning, and presses students to reflect on building on their own thinking. Errors are used as opportunities to reconceptualize problems, explore contradictions, and seek alternative strategies and explanations.

Equity

High Expectations				
1	2	3	4	5
Teacher only calls on or engages a few students fully in the lesson. No reassurance that students are capable or ideas are valued. Participation is very uneven across cultural and gender groups.	Teacher calls on or engages some students in the lesson with little encouragement that they are capable or that ideas are valued. Participation is solicited unevenly across cultural and gender groups.	Teacher attempts to engage all students, but relies on a subset (e.g. students with correct answers). Teachers states, but does not reinforce, that all ideas are valued. Participation is uneven across cultural and gender groups.	Teacher engages most students in the lesson with repeated encouragement and valuing of students' ideas. Even participation across cultural and gender groups.	Teacher engages all or most students fully in the lesson with the constant reassurance that they are capable and that their ideas are valued. Participation solicited evenly across cultural and gender groups.
Cultural Connections				
1	2	3	4	5
No references in lesson nor evidence in the classroom decor of cultural or gender group contributions to math and science. No references of impact on students' home culture. Stereotypes and biases were not discussed.	Some evidence in room displays of cultural and gender group contributions to math and science, or of impact on home cultures, but no references observed in the lesson. Stereotypes and biases were not discussed.	Brief comment made regarding contributions of cultural and gender groups or impact on students' own home cultural environments, but peripheral to lesson. Stereotypes and biases that arose were acknowledged but not discussed.	Lesson attempts to bring in cultural and gender group contributions to math and science or attempts to relate lesson to students' home cultures. Stereotypes and biases that became evident during the lesson were challenged and discussed.	Lesson meaningfully integrates the contributions of cultural and gender groups or integrates the impact of math and science can or does have on students' own home environments. Discussion of stereotypes and biases was integrated into the lesson.

Community of Learners

Interactions				
1	2	3	4	5
Class is a collection of individuals. No or very few exchanges between peers in small or whole group settings. Exchanges among peers focus mainly on off-task topics.	Students sit in small groups or as pairs for all or part of the lesson, but exchanges focus only on sharing of materials and answers.	Some students are engaged in collaborative working relationships, exchanging ideas, reasoning, and solutions strategies.	Many students are engaged in collaborative working relationships, responding to one another's ideas and solutions, and trying to understand the validity of alternative approaches and answers.	Class is a learning community. All or most students participate in substantial exchanges among peers in small or whole group settings in order to compare and merge their observations to make sense of mathematical and scientific ideas.
Intellectual Engagement				
1	2	3	4	5
Students are not intellectually challenged (e.g. busy or rote work) but are compliant in performing requested actions, not on task, occasionally on task, or involved in disruptive disengagement.	Students are briefly challenged to reason but they do not respond, put forth little effort to become involved, or the teacher provides the responses.	Sporadic or episodic intellectual challenges move students to become involved, but it is inconsistent, mildly enthusiastic, or dependent upon frequent prodding from the teacher.	For much of the lesson, students are challenged to reason about math and science concepts and may students discuss issues and important ideas with some enthusiasm and interest.	Students are challenged intellectually with important mathematical and scientific ideas throughout the lesson. All or most students are actively and consistently involved, excited, and interested.
Source of Knowledge				
1	2	3	4	5
Only teacher and text materials are recognized, used, and valued as sources of knowledge and authority.	Acknowledgment that sometimes students can be a knowledge source, but they are not used or provided with an opportunity to be a source. Authority remains with teacher and text materials.	Acknowledgment of students as a source of knowledge, and they are given opportunities to generate ideas and strategies. Much reliance still on teacher, text or other outside entities as authorities.	Students are recognized as a source of knowledge, and some students join in the process of generating ideas, conjectures, and strategies. Evidence of teacher not being the ultimate authority.	All students are recognized and valued as knowledge sources and play an integral part as knowledge sources throughout the lesson as they generate ideas, conjectures, strategies and approaches. Evidence of students as authorities.

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